ORGANIC ELECTRONIC DEVICES WITH PRESSURE SENSITIVE ADHESIVE LAYER

FIELD OF THE INVENTION

The present invention relates to organic electronic devices that are protected from environmental elements such as moisture and oxygen.

BACKGROUND OF THE INVENTION

Organic electronic devices including circuits, for example, organic light emitting diodes, organic electrochromic displays, organic photovoltaic devices and organic thin film transistors, are known in the art and are becoming increasingly important from an economic standpoint.

As a specific example, organic light emitting devices ("OLEDs"), including both polymer and small-molecule OLEDs, are potential candidates for a great variety of virtual- and direct-view type displays, such as lap-top computers, televisions, digital watches, telephones, pagers, cellular telephones, calculators and the like. Unlike inorganic semiconductor light emitting devices, organic light emitting devices are generally simple and are relatively easy and inexpensive to fabricate. Also, OLEDs readily lend themselves to applications requiring a wide variety of colors and to applications that concern large-area devices.

In general, two-dimensional OLED arrays for imaging applications are known in the art and typically include an OLED region, which contains a plurality of pixels arranged in rows and columns. FIG. **1**A is a simplified schematic representation (cross-sectional view) of an OLED structure of the prior art. The OLED structure shown includes an OLED region **15** which includes a single pixel comprising an electrode region such as anode region **12**, a light emitting region **14** over the anode region **12**, and another electrode region such as cathode region **16** over the a light emitting region **14**. The OLED region **15** is disposed on a substrate **10**.

Traditionally, light from the light-emitting layer **14** passed downward through the substrate **10**. In such a "bottom-emitting" configuration, the substrate **10** and anode **12** are formed of transparent materials. The cathode **16** and cover **20** (i.e., barrier), on the other hand, need not be transparent in this configuration.

Other OLED architectures are also known in the art, including "top-emitting" OLEDs and transparent OLEDs (or "TOLEDs"). For top-emitting OLEDS, light from the light emitting layer **14** is transmitted upward through cover **20**. Hence, the substrate **10** can be formed of opaque material, while the cover **20** is transparent. In top-emitting configurations based on a design like that illustrated in FIG. **1**A, a transparent material is used for the cathode **16**, while the anode **12** need not be transparent.

For TOLEDS, in which light is emitted out of both the top and bottom of the device, the substrate **10**, anode **12**, cathode **16** and cover **20** are all transparent.

Structures are also known in which the positions of the anode **12** and cathode **16** in FIG. **1**A are reversed as illustrated in FIG. **1**B. Such devices are sometimes referred to as "inverted OLEDS".

In forming an OLED, a layer of reactive metal is typically utilized as the cathode to ensure efficient electron injection and low operating voltages. However, reactive metals and their interface with the organic material are susceptible to oxygen and moisture, which can severely limit the lifetime of the devices. Moisture and oxygen are also known to produce other deleterious effects. For example, moisture and oxygen are known in the art to increase "dark spots" and pixel shrinkage in connection with OLEDS.

With the aid of a sealing region **25**, the cover **20** and the substrate **10** cooperate to restrict transmission of oxygen and water vapor from an outer environment to the active pixel **15**. Typically, the cover **20** is attached to the substrate **10** via sealing region **25** under a clean, dry, inert atmosphere.

Sealing region **25** is commonly an epoxy resin adhesive. Epoxy resins, however, are typically not flexible, rendering these materials undesirable for use in connection with flexible OLEDs (or "FOLEDS"). In addition, because they are typically inflexible, because they are not pressure sensitive, and because they are typically applied in liquid form, epoxy resins are not readily adaptable for use in web-based manufacturing techniques. Moreover, epoxy resins frequently contain ingredients that are deleterious to OLEDS. Analogous difficulties are encountered in organic electronic devices other than OLEDS.

SUMMARY OF THE INVENTION

The above and other challenges of the prior art are addressed by the present invention.

According to a first aspect of the invention, an organic electronic device structure is provided, which comprises: (a) a substrate layer; (b) an organic electronic region disposed over the substrate layer; (c) a pressure sensitive adhesive layer disposed over the organic electronic device; and (d) a barrier layer disposed over the adhesive layer. In many preferred embodiments, the organic electronic device region is an OLED region.

The adhesive layer can be disposed over all or a portion of the organic electronic region. For example, the adhesive layer can be, for example, in the form a continuous layer that is disposed over the entire organic electronic region or in the form of a ring that is disposed over only a portion of the organic electronic region.

The adhesive layer may be, for example, a low-temperature-curable adhesive layer. In preferred embodiments, the adhesive layer is a radiation-curable adhesive layer, more preferably an ultraviolet-radiation-curable adhesive layer. The adhesive layer also preferably displays low out-gassing of harmful species, as defined hereinbelow.

In many embodiments, the organic electronic device structure will include a getter material, which can be provided within the adhesive region, if desired, or elsewhere.

Preferred substrate layers, and barrier layers, for use in the organic electronic device structures of this aspect of the present invention include metal layers, semiconductor layers, glass layers, ceramic layers, polymer layers and composite material layers. Where a composite material layer is selected, it preferably comprises (a) a polymer substrate sub-layer and (b) at least two alternating pairs of high-density sub-layers and planarizing sub-layers. The planarizing sub-layers may be the same or different from each other, as can the high-density sub-layers.

In some instances, it is preferred to include a protective layer between the organic electronic region and the adhesive layer of the organic electronic device structure. The protective layer comprises, for example, a material selected from a silicon oxide, a silicon nitride, a silicon oxynitride, a metal oxide, an organic compound and an organometallic compound. As another example, the protective layer comprises one or more high-density sub-layers and one or more planarizing sub-layers.